Kansas Agricultural Experiment Station Research Reports

Volume 5
Issue 4 *Kansas Fertilizer Research*

Article 7

2019

Correlation Between Mehlich-3 and Ammonium Acetate Extractable Potassium in Kansas Soils

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Recommended Citation

Rutter, B. and Ruiz Diaz, D. A. (2019) "Correlation Between Mehlich-3 and Ammonium Acetate Extractable Potassium in Kansas Soils," *Kansas Agricultural Experiment Station Research Reports*: Vol. 5: Iss. 4. https://doi.org/10.4148/2378-5977.7759

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Abstract

The K-State Research and Extension Soil Testing Laboratory has been using Mehlich-3 soil test procedures for phosphorus (P) extraction, and ammonium acetate extraction for potassium (K). Previous research in other states has shown a strong correlation between these two tests for K, but data correlating the two in Kansas soils have been limited. A study was performed on soils from across the state to investigate the relationship between these two methods. A strong positive correlation was observed (r = 0.99) across the wide range of soil types, pH, and fertility conditions represented in the sample set. Linear regression suggests a near 1:1 relationship and strong fit between Mehlich-3 and ammonium acetate extractable K (slope = 0.97, R^2 = 0.98). Based on these results the Mehlich-3 procedure for soil K analysis is a suitable for Kansas soils.

Keywords

potassium, Mehlich-3, ammonium Acetate, correlation

Correlation Between Mehlich-3 and Ammonium Acetate Extractable Potassium in Kansas Soils

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Summary

The K-State Research and Extension Soil Testing Laboratory has been using Mehlich-3 soil test procedures for phosphorus (P) extraction, and ammonium acetate extraction for potassium (K). Previous research in other states has shown a strong correlation between these two tests for K, but data correlating the two in Kansas soils have been limited. A study was performed on soils from across the state to investigate the relationship between these two methods. A strong positive correlation was observed ($r = 0.99$) across the wide range of soil types, pH, and fertility conditions represented in the sample set. Linear regression suggests a near 1:1 relationship and strong fit between Mehlich-3 and ammonium acetate extractable K (slope = 0.97, $R^2 = 0.98$). Based on these results the Mehlich-3 procedure for soil K analysis is a suitable for Kansas soils.

Introduction

Potassium is an essential plant nutrient and is the third most common yield-limiting nutrient in agricultural production. The bioavailability (solubility) of soil-K is governed by equilibrium reactions between three main pools: nonexchangeable-K (K_{non}), exchangeable-K (K_{ex}), and soluble-K (K_{sol}). In many soils, the vast majority of total soil-K exists in the K_{non} pool, where K is either trapped between clay platelets or fixed in the crystalline structures of various minerals (e.g. orthoclase and feldspars). Exchangeable-K is associated with cation exchange sites and may enter the soil solution via displacement from soil colloid surfaces. Soluble-K consists of K^+ ions in the soil solution, which is immediately available for plant uptake but is also the smallest soil-K pool. Even though K_{non} is typically much larger than both K_{ex} and K_{sol} combined, the latter are of particular importance to agriculture, as they represent the bulk of soil-K available for plant uptake over a given growing season. As such, most soil tests for K target the K_{ex} and K_{sol} pools, and are used in combination with fertilizer response curves to make K fertilizer recommendations.

Several soil tests for K are currently employed by laboratories across the U.S.; however, ammonium acetate (NH_4OAc) and Mehlich-3 (M3) are currently the most popular. The KSRE soil testing lab uses M3 for soil phosphorus, but continued using NH_4OAc for soil tests for K. While there are some contrasting chemical characteristics between these two solutions (e.g. pH), the primary mechanisms for K extraction are similar in theory. Primarily this should occur through displacement of K^+ from the cation exchange complex by NH_4^+. As both solutions contain NH_4^+ and have similar reaction times (shake times), the amount of K^+ extracted should be similar for a given soil. Researchers in other states have demonstrated a near 1:1 correlation between measurements made from these two procedures, however, data correlating the two methods have been limited in Kansas soils. The objectives of this study were to investigate the relationship between NH_4OAc and M3 extractable K, and determine whether M3-K can directly replace NH_4OAc-K in K fertilizer application rate calculations for crops grown in Kansas soils.

Procedures

Laboratory Analysis

Soil samples were randomly selected from soils submitted to the KSRE soil testing lab by farmers and homeowners during 2016-2017 year. Each sample was dried at 40°C and ground to pass a #10 sieve (2 mm). Samples were measured into extraction vessels using 2 g standard soil scoops (NCR) and extracted according to the procedures described in the NCERA 013 *Recommended Chemical Soil Test Procedures* handbook. Briefly, extractions were performed using a 1:10 soil-extractant suspensions of either M3 (0.2 M CH_3COOH, 0.25 M NH_4NO_3, 0.015 M NH_4F, 0.013 M NHO_3, 0.001 M EDTA; pH = 2.5 0.1) or NH_4OAc (1.0 M NH_4OAc; pH 7.0 0.1), with a reaction time of 5 minutes. Extracts were filtered using Ahlstrom 642 filter paper and analyzed using a PerkinElmer Aanalyst 200 Atomic Absorption Spectrometer. The relationship between Mehlich-3 and NH_4OAc extractable K was investigated using linear regression procedures.

Results

A total of 776 samples from 46 different counties in Kansas were included in the study (Table 1). A strong positive correlation was observed between NH_4OAc-K and M3-K over the entire data set (r = 0.99) (Table 2), values for which ranged from 50 to 960 ppm and 41 to 991 ppm, respectively. The near 1:1 relationship (Figure 1) and standard error of the linear regression model (0.97 and 0.005, respectively) suggest that M3-K values could be used as direct replacements of NH_4OAc-K values when calculating fertilizer recommendations without recalibration.

Table 1. General summary of samples used in the study, soils from 46 Kansas counties were used in the study, and covered a wide range of soil pH, Mehlich-3 K (M3K) and ammonium acetate-K (AAK)

Value	pH	M3K	AAK
		----------------- soil ppm, mg/kg -----------------	
Minimum	4.0	41.0	50.0
Mean	6.6	238.3	237.2
Maximum	8.5	991.0	960.0

Table 2. Regression analysis results indicate a strong relationship between Mehlich-3 K (M3K) and ammonium acetate-K across the range of soil type, pH, and fertility conditions of samples included in the study

	Estimate	Standard error	t value	Pr(>|t|)
Intercept	7.127	1.357	5.252	1.948e-07
M3K	0.9655	0.004714	204.8	0

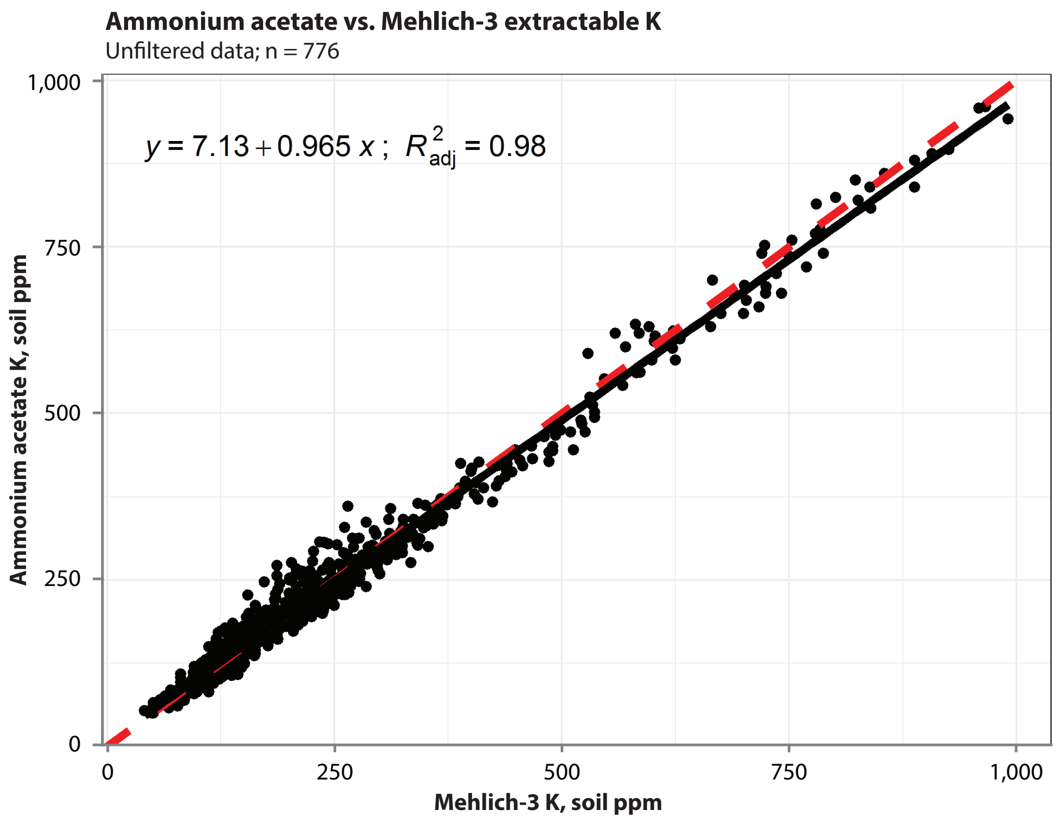

Figure 1. A strong and positive correlation was observed between Mehlich-3 and NH_4OAc extractable potassium (K) over a wide range of soil types and K concentration. The near 1:1 fit and strong fit of the model (slope = 0.97, R^2 = 0.98) suggest Mehlich-3 K may be a suitable replacement for NH_4OAc-K in K fertilizer recommendations.